University of Alberta

Concordance Among Physician and Nurse Practitioner Interpretation of Exercise Stress Test Recordings

by

Evelyn Anne Maier

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Nursing

Faculty of Nursing

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Concordance Among Physician and Nurse Practitioner Interpretation of Exercise Stress Test Recordings** by Evelyn Anne Maier in partial fulfillment of the requirements for the degree of Master of Nursing.

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Abstract

Exercise Stress Tests (ESTs) are used to diagnose and evaluate ischemic heart disease. It was hypothesized that a Nurse Practitioner (NP) would come to similar conclusions as Cardiologists when both interpreted identical EST data. Each rater retrospectively evaluated 100 EST recordings independently on 5points: baseline rhythm, baseline ST levels, arrhythmias during EST, peak ST levels, and EST diagnosis (positive, negative, or inconclusive). Comparisons were also done to computer generated-averaged data. Results expressed in Kappa values among raters were: baseline rhythm was high; arrhythmias during EST was moderate; EST diagnosis was moderate. Pearson correlation values among raters were high for baseline ST levels; moderate to low for peak ST levels; moderate to high for computer generated-averaged baseline ST levels; moderate to high for computer generated-averaged peak ST levels. It was concluded that NP interpretation of ESTs was as reliable as those of Cardiologists.

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CHAPTER ONE

Introduction

The widespread need to contain and reduce health care costs while at the same time maintain an optimum level of health care has led to an in-depth examination of the role, preparation, and employment of Nurse Practitioners. The Nurse Practitioner (NP) role originated in the 1960's as a result of the pioneering work done by Loretta Ford and Henry Silver at the University of Colorado (Silver, Ford, & Stearly, 1967). In Canada the need to provide adequate medical services to the under serviced far north and rural communities resulted in the implementation of the NP role in primary health care in the early 1970's. More recently, changes in health care delivery and the decreased availability of medical residents resulting from both changes in scheduling and from a decrease in numbers, has brought about the establishment of the NP role in acute care settings (Knickman, Lipkin, Finkler, Thompson, & Kiel, 1992).

The role of the NP as with all new roles brings challenges and requires validation. The value, practicality, and safety of this new breed of practitioner merits examination. Nurse Practitioners must constantly justify their existence (Buppert, 1995). Since the study done by Silver et al. (1967), a plethora of studies examining the role, cost efficiency, and competency of NPs have been completed. Earlier studies concentrated on examining role and efficacy issues as well as patient satisfaction and outcomes (Spitzer et al., 1974; Goodman & Perrin, 1978; Thompson, Badsen, & Howell, 1982). As Nurse Practitioners moved into the acute care setting, further studies were directed at comparing Nurse Practitioners to medical residents and physicians (Chang et al., 1999; Sakr et al., 1999). In comparison, NPs were equal to or better than physicians in patient satisfaction and

treatment outcomes, reducing hospital length of stay, recording medical histories, accuracy of physical examination, adequacy of treatment, planned follow-up, and requests for and interpretation of radiographs (Spitzer et al., 1974; Everitt, Avorn, & Baker, 1990; Avorn, Everitt, & Baker, 1991; Sakr et al.,1999; Russell, Vorderbruegge, & Burns, 2002). Consequently, the role of Nurse Practitioner is constantly evolving as nurses broaden their scope of practice in collaboration with the medical community.

Cardiology is one specialty area in acute care that has implemented the NP role. Although coronary artery disease mortality has decreased significantly in the last two to three decades in more developed countries, the rapid aging of our populations is expected to increase the prevalence of this disease (Rosamond et al., 1998). Hospitalizations related to cardiovascular disease are projected to increase through to the year 2016, while deaths due to various forms of cardiovascular disease are projected to decrease through this same time frame (Heart and Stroke Foundation of Canada, 1999). The occurrence of stable angina or a myocardial infarction is typically the first clinical manifestation of coronary artery disease in patients. It is estimated that there are 30 patients with stable angina for every patient that is hospitalized for acute myocardial infarction (AMI) (ACC/AHA/ACP ASIM Guidelines, 1999). This estimate is extrapolated from data on two population-based studies from Olmsted County, Minnesota (Elveback & Connolly, 1985) and Framingham, Massachusetts (Kannel & Feinleib, 1972). The Heart and Stroke Foundation of Canada statistics for 1999 put cardiovascular diseases as the leading cause of death in Canada, accounting for 36% of all deaths. The estimated cost of heart disease including lost wages and productivity in 1999 was 12.4 billion dollars annually. In Alberta alone, 784 males and 593 females died of heart attack. Projected hospitalizations

in Canada for 2006 are 36,000 for males and about 17,000 for women (Heart and Stroke Foundation of Canada, 1999).

Not only is ischemic heart disease important because of its prevalence but also because of the associated morbidity and mortality. Mortality in the first year following a myocardial infarction is approximately 10%. Another 40% to 50% of AMI patients will experience another significant coronary event such as reinfarction, the need for revascularization, or the development of congestive heart failure, often within the first six weeks to three months following an AMI. Early detection and risk stratification of these patients is very important. "Although limitations exist, exercise stress testing has remained the most universally available method for the initial prognostication of patients with an AMI" (Senaratne, Smith, & Gulamhusein, 2000). Exercise Stress Testing (EST) is a procedure recently conducted by Nurse Practitioners. Unfortunately there is a paucity of research examining the efficacy and safety of NPs in Cardiology, and more specifically in the area of Exercise Stress Testing. Two areas that have been researched in Cardiology include a Heart Failure Program directed by an NP (Dahl & Penque, 2000), and the impact of NPs in an Interventional Cardiology Program implementing "best practice" clinical pathways (Bargardi & Starling, 1999). More specific to Exercise Stress Testing, the first study published was related to the safety of having a nurse supervised EST Laboratory, without direct supervision of a physician (Lem, Krivokapich, & Child, 1985). The conclusion of the study was that nurses could safely and effectively supervise stress testing while maintaining low morbidity and mortality rates. Zecchin et al. (1999) published a study from Australia, again dealing with the safety of a NP run EST Laboratory. This study also confirmed that nurses in the EST Laboratory were both safe

and effective. While the safety and efficacy of NPs doing ESTs has been studied, no published studies have examined the reliability of interpretations of ESTs between physicians and NPs.

Purpose of the Study

The objective of this study was to examine the reliability of a Nurse Practitioner (NP) in evaluating ischemia on the basis of electrocardiogram (ECG) analysis during an EST. This evaluation was conducted by establishing the concordance among a NP and two Cardiologists (C1 and C2). The hypothesis was that a NP would obtain results concordant with those of the Cardiologists. The specific aims were to determine the agreement among the NP and Cardiologists in:

1. diagnosing the exercise stress tests as positive, negative, or inconclusive on EST recordings.
2. determining the type of arrhythmias and conduction abnormalities at baseline and during exercise on EST recordings.
3. determining the quantitative measurement of ST segment levels at baseline and peak exercise on EST recordings.
4. comparing the computer generated-averaged quantitative measurement of ST segment levels at baseline and peak exercise on EST recordings.

Significance of the Study

The significance of this study was to provide objective data on the reliability of a Nurse Practitioner in performing interpretations of EST recordings. Having a Nurse Practitioner without a Cardiologist physically present frees up the Cardiologist's for other duties, while maintaining their involvement in a consultancy role. The benefit of having

the majority of the EST done by one individual also provides continuity and consistency. Consistency in execution of the EST would also ensure that the results would be interpreted in a reliable manner and guidelines for referral maintained. It is also important for the NP role to be fully accepted and supported by physicians if it is to be expanded (MacDonald & Katz, 2002).

CHAPTER TWO

Literature Review

The literature based on a Medline (1966- July 2002), CINAL (1982 – July 2002), and EMBASE (1988 – April 2000) database search was reviewed and summarized. Literature on the reliability of Nurse Practitioners doing ESTs is limited.

Advanced Nursing Practice

The Alberta Association of Registered Nurses in its 1992 Scope of Nursing Practice paper stated that nursing practice can be viewed on a continuum from basic to advanced service. "Nurses with additional education, experience and highly specialized skills provide care in complex clinical situations, manage health promotion programs in the community, develop healthy public policy, provide leadership in the provision of health care and health care reform, and advance nursing knowledge through nursing research" (p.3). The definition of advanced nursing practice in its broadest form would include Clinical Nurse Specialist (CNS), Nurse Practitioner (NP), Certified Nurse Midwife (CNM), and Certified Registered Nurse Anesthetist (CRNA). The role and scope of advance nursing practice continues to be defined and delineated both through practice and research. American NPs were first recognized in the late 1800's when nurses began administering anesthesia. Nurse midwives working in rural areas to provide necessary services followed. The role evolved further in the mid 1960's with the initiation of a pediatric nurse practitioner program at the University of Colorado in 1965 by Dr. Henry Silver and a nurse, Loretta Ford (O'Mally, 1995). Silver and Ford's efforts helped to launch the wider acceptance of the role of Nurse Practitioner in the United States and abroad.

In Canada, nurses have been using advanced practice skills to serve populations in the far north and in rural areas lacking physicians; however, legal recognition of their services has not come easily. Canada has been the last industrialized country to legalize midwifery practice and most of the progress towards the legalization of midwives has occurred in the past decade (Blais & Joubert, 2000). In Alberta, the Alberta Health Guidelines for Registered Nurses in Advanced Nursing Practice Providing Primary Health Service in Under-Serviced Communities (August, 1994) document stated, "While registered nurses have been carrying out aspects of this new role for many years, barriers have prevented competent registered nurses from practicing to the full extent of their abilities" (p. 6). The document also recognized that further work is needed until full integration has occurred. Nurses are continuing to fill a need for competent health care services in the rural and far northern areas of Alberta and Canada.

While nurses have been utilizing advance practice skills both in a formal and informal manner in rural areas for many decades, the move into acute care settings has taken longer. Developments within the past couple of decades have been changing the health care setting. Fiscal pressures to deliver health care in a cost-effective manner have produced some dramatic changes. Only the sickest patients are being admitted to hospital, and length of stay has been reduced dramatically. Hospital acuity has risen significantly within the past few years (Shah, Bruttomesso, Sullivan, & Lattanzio, 1997). The pressure to reduce the supply of physicians and thereby decrease training programs and residencies (Knickman et al., 1992) has created a critical shortage of skilled practitioners in an environment of increased acuity. The desire for continuing quality care within this environment has presented the opportunity for nurses with advanced education and skills

to help fulfill the need and bridge the gaps that have resulted. In 1995, the first national credentialing certification exams were offered for Acute Care Nurse Practitioners in the United States (Kleinpell, 1998). The role and scope of practice for the acute care nurse practitioner has thus been evolving continually from its inception.

Scope of Advanced Nursing Practice

There is a lack of clarity in defining the role of the acute care nurse practitioner (ACNP) in al l centers where the roles have been implemented, including Canada, the United States, Australia, or Britain (Newbold, 1996; Daffurn, 1998; Kleinpell, 1998). However, some commonalities have been reported, that transcend borders and nationalities. In the United States, the 1998 study done by Kleinpell identified that the major role component of the Nurse Practitioner was managing patient care. More specifically, the most frequent tasks reported were conducting patient history and physical examination; initiating or changing orders in the patient's plan of care; making hospital rounds; performing therapeutic procedures and treatments; initiating transfers and discharges; and seeking or giving consultations with other care providers. ACNPs reported that the site at which they practiced and the patient population they cared for most frequently determined the procedural involvement and level of responsibility. Daffurn (1998), reporting on role responsibilities of ACNPs in an Australian hospital, has listed many of the same functions as noted by Kleinpell.

Many of the specific tasks and procedures performed vary according to the specialty of the NP and to the limitations legislated by the province, territory, or state where the care is implemented. The degree of autonomy exercised by each NP also varies by region and area of specialty. The United States is leading nations with the degree of autonomy it

affords Nurse Practitioners. In all the States, Nurse Practitioners have a certain amount of independent authority to prescribe drugs. Direct Medicaid reimbursement has also been established for every State as part of the 1997 Balanced Budget Act (Mundinger et al., 2000).

In Canada, Ontario published a position paper (The Ministry of Health, Office of the Nursing Co-Ordinator) in 1994 asking for the preparation of a category of nurse that will provide within the jurisdiction of nursing, a safe, cost-effective measure of care covering all aspects of the health care continuum including promotion, prevention, cure, rehabilitation, and support. The paper goes further to state that Advance Nurse Practitioners are not second level doctors or physician's assistants but provide services in the area of cure (assessment, diagnosis, and treatment) that can safely be provided by both doctors and nurses. In Ontario, Nurse Practitioners are prepared to work both independently and in partnership with others; however, the level of independence is not well defined.

In Alberta, autonomous care by Nurse Practitioners has primarily been limited to rural and Northern areas. In the early 1970's the first Nurse Practitioner program in Canada was implemented at the University of Alberta to prepare nurses to work in Northern Canada. Unfortunately this program was short lived. Today Nurse Practitioners are no longer relegated to outlying areas and are now involved in the acute care setting, including critical care. As NPs are given more independence and latitude in their work environment, the question of nurse practitioner effectiveness has arisen (Newbold, 1996; Daffurn, 1998).

Effectiveness of Nurse Practitioners

With the advent of NPs has come the concern whether they would be able to effectively provide safe, quality care (Buppert, 1995; Newbold, 1996). Many studies have been published over the short time span that NPs have been practicing, with the majority showing equivalent to better patient care when contrasted with the care given by physicians (Avorn, Everitt, & Baker, 1991; Hall et al., 1990; Everitt, Avorn, & Baker, 1990; Hill, Bird, Harmer, Wright, & Lawton, 1994; Mundinger et al., 2000), yet "nurse practitioners constantly have to justify their existence" (Buppert, 1995, p. 53).

There are two aspects of NP care that have been examined: process and outcomes of care (Everitt, Avorn & Baker, 1990; Avorn et al. 1991; Mundinger et al., 2000) and complexity of patient care (Moody, Smith, & Glen, 1999). Satisfaction surveys studying the patient provider relationship and outcome studies give information on the reception and acceptability of the Nurse Practitioner role to society and to the population being served. Typically results showed no significant difference in care given by NPs to that given by physicians (Chang et al., 1999; Mundinger et al., 2000).

Effectiveness studies have been conducted in a wide variety of clinical situations including outpatient departments and physician's offices (Thompson, Basden, & Howell, 1982; Hall et al., 1990; Mundinger et al., 2000), long term and rehabilitative care (Hill, Bird, Harmer, Wright, & Lawton, 1994), emergency (Chang et al., 1999), critical care units (Hanneman, Bines, & Sajtar, 1993; Russell, VorderBruegge, & Burns, 2002), orthopedic (Overton-Brown & Anthony, 1998), surgical units (Hylka & Beschle, 1995) and pediatric and neonatal units (Bissinger, Allred, Arford, & Bellig, 1997). In the large majority of these clinical situations, Nurse Practitioners have been found to be both a

practical and economical solution to physician staffing shortages.

Nurse Practitioners have been found to be both thorough and comprehensive in their evaluation and treatment of patients. A large randomized controlled trial conducted in Ontario from July, 1971 to July, 1972 (Spitzer et al., 1974) found no differences in physical functional capacity, social function, or emotional function between groups of patients cared for by Nurse Practitioners and physicians. Satisfaction was also rated high by both patients and professionals. This study provided quantitative evidence that using non-physicians to provide primary health care is both safe and effective.

Everitt et al. (1990) evaluated the decision-making ability of Nurse Practitioners and physicians in the treatment of insomnia. In this study, Nurse Practitioners were more likely to ask patients questions and elicit a sleep history from the patient than physicians (60% NP's took histories as opposed to 47% physicians). Physicians were also more likely to prescribe medication as the main therapy therapy as opposed to 17% of Nurse Practitioners. Nurse Practitioners were shown to be more thorough in their history taking and more likely to use a non-pharmacologic approach to treating patients. Another study (Avorn et al., 1991) was done where a large random sample of NPs and physicians were given a case vignette describing a patient with epigastric pain and an endoscopy video showing diffuse gastritis. The history contained very relevant details such as substantial use of aspirin, coffee, cigarettes, and alcohol as well as severe psychological stress. More than one-third of the physicians initiated therapy without obtaining further history, compared to 19% of the Nurse Practitioners. Only 20% of the NPs recommended prescription medication, while 65% of the physicians recommended a histamine antagonist.

Another study (Freij, Duffy, Hackett, Cunningham, & Fothergill, 1996) compared NP's and physician's abilities to request and interpret radiographs. No significant difference was found. This study concluded that appropriately trained Nurse Practitioners were as competent as casualty officers in ordering and interpreting radiographs. A British study (Overton-Brown & Anthony, 1998) compared junior doctors and Nurse Practitioners in their ability to diagnose extremity x-rays. When this was compared with the gold standard of the consultant radiologist, no significant difference was found between the two groups.

The number of tests ordered does not necessarily increase with the use of Nurse Practitioners. Shackelford, Griffin, Hoffman, and Jones (1999) reviewed the influence of specialty on pathology resource use and found that gynecologists obtained fewer biopsy tests than non-gynecologists, while at the same time diagnosing cervical dysplasia as well as the non-gynecological providers. The authors concluded that gynecologists were more efficient at doing colposcopies than non-gynecologists. The study included Nurse Practitioners as well as physician non-gynecologists; however, no statistics were compiled for the Nurse Practitioner group alone.

A study (Sakr et al., 1999) done in the United Kingdom assessed the care of emergency patients cared for by junior physicians and Nurse Practitioners. In this study, the Nurse Practitioners were more complete than the junior doctors at recording medical histories and fewer patients seen by the NPs in this study had to seek unplanned follow-up advice. No significant differences were found between the two groups in the accuracy of examination, adequacy of treatment, planned follow-up or requests for x-rays. The rate of error made by the two groups was not statistically different; 9.2% of 704 patients for

the NP group, versus 10.7% of 749 patients seen by the junior physicians. The care given by both groups was analyzed for minor injuries such as lacerations, crush, blunt and or sprain injuries to the extremities caused by falls or inanimate mechanical force.

A six-month trial (Hanneman, Bines, & Sajtar, 1993) was done contrasting the pulmonary complications of patients in two critical care units, one unit receiving interventions by a Clinical Nurse Specialist (CNS), the other unit receiving the standard protocol of having the CNS available only when specially requested by the staff. Although the acuity of the illnesses were somewhat greater in the unit receiving special attention by the CNS, the incidence of pulmonary complications were reduced in comparison to the standard protocol unit. Another study examined care given by Nurse Practitioners in contrast to the regular team care approach in a Neuroscience intensive care unit or neurosurgery unit. Nurse Practitioner managed patients spent an average of 3 days less in hospital with fewer complications adding up to a significant cost saving for the institution (Russell, VorderBruegge, & Burns, 2002).

Lombness (1994) examined the length of stay of 105 randomly selected patients that had undergone elective coronary artery bypass surgery. Either a Clinical Nurse Specialist or a physician's assistant managed patient care. Both groups were co-managed by cardiac surgeons. This retrospective chart review indicated that patients whose care was managed by the CNSs had reduced time in the hospital and experienced fewer complications than those patients managed by physician's assistants. The Clinical Nurse Specialist, like the Nurse Practitioner, has advanced education and an extended role requiring critical thinking and critical judgment skills. Physician's assistants on the other hand are more likely to carry out primarily technical duties.

More specific to Cardiology, a Nurse Practitioner directed heart failure program was evaluated as to patient outcomes such as mortality, hospital re-admission rates, and patient adherence to recommended outlines (Dahl & Penque, 2000). Patients who received care managed by the Nurse Practitioner had decreased rates of hospital readmission than patients who had not participated in the program when evaluated at 30 and 90-day intervals. An improvement was also noted in patients' adherence to medication and dietary recommendations.

Advanced Nursing Practice in EST

While nursing and other health personnel have done exercise stress testing, there is a limited amount of research to date involving the testing of cardiac patients in an acute care setting. Lem, Kripokapich, and Child published results of nurse supervised ESTs in 1985. This was the first published study assessing the safety of nurses supervising ESTs. In this study a small percentage of patients were considered high risk and a cardiology fellow tested those with a recent AMI. The morbidity rate of this study was low at 0.12%, with a zero mortality rate.

A study (Zecchin, Chai et al., 1999) originating in Sydney, Australia looked at the safety of nurses conducting Exercise Stress Tests on higher risk patients in a hospital-based cardiac rehabilitation setting. This study was a retrospective audit of Exercise Stress Tests recordings including 17, 467 tests performed on 5054 patients over a period of 12 years. The nurses were Registered Nurses with a Cardiology background and advanced skills in ECG analysis. Advanced life support and completion of a specialized training program were also requirements for the position. The population being tested included patients that would be categorized in most institutions as being at a higher risk

for complications. These consisted of those with a diagnosis of recent AMI (within the past 3-10 days), recent documented arrhythmias, heart failure, open-heart surgery, and left ventricular ejection fractions (LVEF) of less than 40%. Major complication rates (0.06%) were defined as patients requiring urgent intervention (sustained VT, defibrillation). Findings were that from a morbidity and mortality perspective, the nurse supervised exercise stress testing was a safe practice.

Other non -physician groups, most notably exercise specialists and physiologists have reported low rates on both morbidity and mortality in ESTs supervised by these specialties (Franklin et al., 1990; Knight, Laubach, Butcher, & Menapace, 1995; Squires, Allison, Johnson, & Gau, 1997). However, Lem et al. (1985) suggested that because nurses have knowledge of the basic sciences, pathophysiology, pharmacology, medical therapy, and mental health and illness, they are well suited to supervise exercise stress tests. Nurses also have the ability to provide emergency care with advanced cardiac life support medications and treatment where necessary, whereas some of the auxiliary professions must rely on nursing help for emergencies.

To date, only one study has reported on the concordance of NP and Cardiologist interpretation of ESTs. The results, published in abstract form by Zecchin, Roach, et al. (1994), found a 94% concordance rate between NP's and Cardiologist's interpretation of the EST. No other corroboration of this finding was found.

Exercise Stress Testing

History of EST

Exercise Stress Testing has been in widespread clinical use for several decades. Bousfield reported in Lancet (1918), a concurrence of angina and ST segment depression

on an electrocardiogram (ECG). In 1928, Feil and Siegel noted the concurrent ST and T wave changes (now recognized to be signs of ischemia) when they exercised patients with known angina. These Exercise Stress Tests were conducted by having the patients do sit-ups (Feil & Siegel, 1928). Through the years stress testing has used a variety of formats, including running up and down stairs and step tests, to test physical fitness for athletes and military personnel. The use of ECGs has also developed from testing with only one lead following exercise, to continuously recording standard leads before, during, and after exercise (Ellestad, Selvester, Mishkin, James, & Mazumi, 1996).

In 1956, Bruce laid the groundwork for the modern day Exercise Stress Test on the treadmill by establishing guidelines and treadmill protocols that would group patients into the New York Heart Disease Functional Classifications, based on exercise performance. The 1960's saw an attempt to extend use of the test beyond the research laboratory by refining criteria for ST segment depression as well as defining critical leads for recording this depression. In the late 1960's, computers were used to analyze ST segments, and the changes were related to coronary angiographic data. This concept of attempting to predict disease prognosis by data provided from the Exercise Stress Test has thus developed during the past two decades (Ellestad et al., 1996). Recent research reported in the New England Journal of Medicine identified that Exercise capacity as determined during an Exercise Stress Test is a powerful predictor of mortality among men with cardiovascular disease (Myers et al., 2002).

Ischemia During Exercise

There are different types of ischemia, some of which are not at all related to a fixed coronary lesion. Typically ischemia results from imbalances between myocardial

oxygen supply and demand. Several mechanisms can contribute to a reduction of blood flow in the coronary vessels. Reduction in arterial vessel size due to an atherosclerotic plaque is only one factor in the equation. A fixed obstruction of 70% is required for the patient to be affected by angina or manifest ischemia. Resistance to blood flow can also be created by vasospam, elevated left ventricular filling pressure in diastole, and tachycardia. Endothelin, a substance found in the cells lining the coronary arteries is an important factor in vasodialation and production of this substance could result in severe vasoconstriction. Thus a patient with even a very minor arterial occlusion might experience significant coronary spasm (Ellestad et al., 1996).

Several mechanisms may trigger ischemia. Altered autonomic tone may be a factor in some cases. Another possibility is thought to be platelet aggregation on the surface of the plaques. Plaque rupture exposes an ulceration, which in turn attracts platelets, triggering ischemia. Thromboxane, a factor in platelet aggregation and also a vasoconstrictor, is increased by coronary atherosclerosis, age, diabetes, mental stress, catecholamines, increased low-density lipoproteins, and vascular trauma. Hyperventilation may be a factor in ischemia by enhancing decreased oxygen release from red blood cells (Ellestad et al., 1996).

Ischemia during exercise can result from any combination of these above mentioned factors such as tachycardia, increased blood flow velocity, hyperventilation, catecholamine release, vascular trauma, increased force of muscular contraction. Exercise Stress Testing by increasing the workload on the heart in a controlled monitored situation can give valuable information as to the etiology of the chest discomfort experienced by a patient. Double product, defined as, heart rate times the systolic blood pressure at the

time of onset of angina or ischemia, is a useful measurement in estimating myocardial oxygen demand in comparison of the timing of events.

Anginal pain, although poorly understood, is an unreliable marker for coronary artery disease. The absence of pain as in the case of silent ischemia does not indicate the absence of coronary disease. The presence of pain may vary from day to day with no explanation or probable cause. However, the early onset of angina during the first stage of an EST may indicate that a patient is at higher risk for a coronary event (Ellestad et al., 1996).

ST Shifts During Exercise

The ST segment is the most frequently monitored indication for ischemia during the Exercise Stress Test. There are other indications of ischemia such as a drop in blood pressure, or arrhythmias, but frequently the most obvious and initial indication for ischemia is a change in the ST segment of the electrocardiogram. The normal ST segment is generally a positive deflection on the ECG due to a difference in polarization in the epicardium and endocardium. Depolarization and repolarization of the endocardium start and end early. The resultant residual voltage differential late in repolarization causes both a positive ST segment and T wave. Ischemia is more severe in the endocardium delaying impulse transmission, resulting in ST depression and T wave inversion or both.

The physiological mechanism is related to a rapid loss of intracellular potassium that results in a current of injury outward to the epicardium. The P and QRS are on an elevated baseline and when ventricular depolarization occurs (QRS) all the myocardial cells including the injured ones are depolarized. There is no current flow at this point (the onset of the ST segment) resulting in the ECG inscription falling below the previously

elevated baseline resulting in ST depression. Again when systole is completed, the injury results in an elevated baseline. As the subendocardial ischemia continues, the ST segment continues to depress further. Although only one area of the heart may have a perfusion deficit the ischemic portion of endocardium is generally well distributed in the ventricle. This mechanism reduces the ability to specify the ischemic territory from the ECG alone. ST depression is best picked up with a bipolar lead positioning the negative lead in the V5 position. ST segment depression and angina do not occur until ischemia has progressed to the point when there is a generalized change in subendocardial blood flow (Ellestad et al., 1996). Multiple lead systems thus reveal more ischemia.

Exercise-induced ST segment elevation in leads with Q waves was originally thought to indicate areas of scaring or aneurysm. More recently it appears that there may still be viable muscle in the area represented by the elevation. "Stunned myocardium" with transmural ischemia might be a more accurate indication as to the process of what is happening. ST elevation in leads with an R wave often represents a severe degree of ischemia (ACC/AHA Guidelines for Exercise Testing, 1997).

CHAPTER THREE

Method

Expertise in determining arrhythmias and ST changes is required to safely conduct an Exercise Stress Test (EST). The detection of seemingly minor changes of ST shifts either positive or negative that can be significant in pointing out coronary artery disease requires training and skill. An understanding of the basic as well as advanced electrocardiogram (ECG) tracing is important in making decisions to continue or stop an EST. The reliability of a Nurse Practitioner (NP) and two Cardiologists in evaluating ischemia on the basis of ECG analysis of EST recordings was examined and further compared to the computer generated averaged measurements.

Design

To examine concordance, a Nurse Practitioner and two Cardiologists (C1 and C2) reviewed and interpreted retrospective EST recordings independently. The Nurse Practitioner has been employed in the role (Appendix A) conducting ESTs since June, 1999. The NP has 15 years experience in Cardiology. Cardiologist (C1) has 14 years experience in diagnostic testing and Cardiologist (C2) has five years experience in the diagnostic aspects of Cardiology.

A pilot study was done with 5 EST recordings to rehearse/standardize the study protocol and criteria for interpretation of EST recordings were understood, and to identify any issues that might arise prior to the study commencing. Several issues arose in the variability of interpretations of the EST recordings such as, which ECG lead to use for interpretation, which line to use for baseline in determining the PR segment, what to do in case of severe artifact at peak exercise, how to define left ventricular hypertrophy,

whether or not to determine ST levels for left bundle branch blocks, and what other variables would indicate the EST recording might be indeterminate. Guidelines to be used during the interpretation of the EST recordings were subsequently developed and used in the stduy (Appendix B).

Sample

A consecutive sample of 100 EST recordings was selected from those ESTs completed from March to July, 2000 at the University of Alberta Hospital. The EST Laboratory billing data were used to identify ESTs done during this time frame. EST recordings were then obtained from patient health records. The first 100 EST recordings not having any of the following exclusion factors were the sample for the study:

1. no indiscernible tracings at baseline, at peak exercise (at end of exercise component), and during the first 5 minutes of recovery. Both the graph paper and ECG tracings had to be clear.
2. no indication that the EST was terminated due to technical errors.

Definition of Terms

Exercise Stress Test (EST)

An EST is "a cardiovascular stress test using treadmill or bicycle exercise and electrocardiographic blood pressure monitoring" (ACC/AHA Guidelines for Exercise Testing, 1997). At the University of Alberta Hospital, the most common form of exercise utilized is the treadmill. Each patient undergoes an uninterrupted multistage treadmill test that terminates when the patient is unable or unwilling to continue, or it is determined that it is unsafe for the patient to continue. The most frequently used protocol on the treadmill is the Bruce protocol. This protocol starts at an initially mild level of 1.7 miles

per hour with a 10% grade in elevation and progresses every three minutes through seven stages that last a total of 21 minutes. Only a well-conditioned athlete is able to fully complete the full 21-minute test. The modified Balke is used very infrequently and mostly in conjunction with a research protocol.

Positive EST

An EST is considered positive for ischemia if there is equal to or more than 1 mm of flat or downsloping ST depression 80 milliseconds from the J point. This has an approximate specificity of 84% (Froelicher, 1994). A test is also considered positive if there is upsloping depression equal to or greater than 1.5 millimeters when measured 80 milliseconds from the J point (Ellestad et al., 1996). This depression must be manifest in a minimum of three consecutive heart-tracing beats. The ST depression must be noted in two or more leads representing inferior, posterior, anterior or lateral walls of the myocardium. This occurs either during the exercise or in the immediate recovery period while the patient is being monitored electrocardiographically.

An EST is also considered positive if ST segment elevation occurs. The segment is considered from the baseline ST level. ST elevation is common in leads with Q wave but rarely seen during exercise in patients with normal resting electrocardiograms. " ST elevation on a normal ECG (other than in leads aVR or V1) represents transmural ischemia (ACC/AHA Guidelines for Exercise Testing, 1997, p. 273)". ST elevation of 1 mm or more from baseline in leads other than V1 and aVR or having a q wave is considered positive for ischemia.

Negative EST

An EST is considered negative when none of the markers of ischemia are noted. A conclusion of negative EST can only be made if a target heart rate was achieved and no other confounding variables are noted that would make the test inconclusive.

Inconclusive EST

Inconclusive EST results indicate that there is not a clear positive or negative indication for ischemia: ST depression in one lead only, upsloping ST depression of less than 1.5 millimeters, or variable ST depression that alternates from beat to beat. An inconclusive interpretation might also result from failure to achieve target heart rate or when the ECG baseline is unclear and thus is difficult to interpret. EST results cannot be interpreted as either truly positive or negative in cases where the patient has taken digoxin within the week prior to testing, a left bundle branch block exists, or ECG tracing with greater than 1 mm depression or elevation can be noted on the baseline ECG at rest. There is also reduced specificity for tracings with left ventricular hypertrophy and ST depression at rest, although sensitivity remains unaffected in this case (ACC/AHA Guidelines for Exercise Testing, 1997).

Target Heart Rate

Target heart rate is calculated as 220 minus age. Heart rate achieved during the EST should be at least 85% of the target. For example, a 60-year-old person would have a target heart rate of 136 (220 – 60 = 160 x .85 = 136).

Baseline

Baseline is considered the segment of the ECG line congruent with the PQ or PR junction.

Data Collection Procedures

EST recordings were obtained from Health Records by a Cardiology medical records technician. To prepare the EST recordings for analysis, research assistants photocopied the resting, peak exercise, and first 2 ECGs recorded in immediate recovery. Patient identification data were covered or cut out of the EST recording photocopy. The research assistants ensured that the photocopy was an adequate reproduction of the original so that interpretation was not difficult or ambiguous to interpret due to poor copy quality.

EST recordings were marked for identification by code numbers, to which only the research assistants had access. A covering data collection sheet was attached for each EST recording (Appendix C). Information collected included the patient's age, medications, risk factors, and BMI that had been identified on the original EST requisition. Reason the EST was requested, protocol utilized during testing, test duration or length, reason for test termination, and presence of angina during the test were also recorded.

The EST recordings were then given to the Nurse Practitioner (NP) and the two Cardiologists (C1 and C2). Each individual worked independently to analyze the EST recordings. Time commitment for each recording involved approximately 20 minutes. Each individual interpreting the EST recordings determined:

1. baseline rhythm.
2. type of arrhythmia or conduction abnormalities at baseline and during exercise.
3. baseline ST segment level in millimeters, 80 milliseconds from the J point. Baseline was to be consistently measured at the PR junction.

4. ST segment level in millimeters, 80 milliseconds from the J point during peak exercise.
5. EST diagnosis of positive, negative, or inconclusive.

The NP's and Cardiologists' measurements of baseline and peak ST segment levels were also compared to the EST computer generated-averaged measurements. This was done by obtaining the original recordings from Health Records after the tracings had been scored. Photocopying of the computer generated-averaged measurements was done once blinding to the patient's EST was no longer needed.

Data Analysis

Descriptive statistics were calculated for age, gender, cardiovascular risk factors identified, medications, EST protocol used, ECG baseline rhythm, arrhythmias during EST, and ST segment levels. Cohen's Kappa coefficients (Fleiss, 1971) were calculated to assess agreement among raters for categorical data, and Pearson's correlation coefficients with regression plots were determined for continuous data. The significance level was $p \leq .05$. For this study, high agreement was considered to be .80, moderate agreement was .60 -.79, and low agreement to be < .60.

Ethical Considerations

The study was approved by the Health Ethics Review Board, Capital Health Region. Care was taken to devoid EST recordings selected for examination of any reference to names. The identity of the patient remained confidential, only know by the research assistant. All data were secured in a locked cabinet.

CHAPTER FOUR

Findings

Concordance in interpretation of EST recordings among a Nurse Practitioner and two Cardiologists (C1 and C2) was examined using retrospective EST recordings. Concordance was evaluated for EST baseline and peak ST levels, EST baseline rhythm, arrhythmias noted during the EST, and EST diagnosis. Also the patient characteristics of age, gender, Body Mass Index (BMI), cardiovascular risk factors, and medications taken were recorded from the patient's health record. EST variables were recorded such as type of EST done, reason for doing the test, length of test, reason for test termination, and whether or not angina was experienced during the EST.

Both SPSS (Version 10) and STAT View statistical packages were used to analyze the data. A descriptive analysis was done of patient characteristics and EST variables. Kappa coefficients were calculated for the categorical variables and Pearson's correlation coefficients with regression plots were conducted for continuous variables. A $p \leq .05$ was considered statistically significant.

Characteristics of Patients Undergoing EST

A total of 105 EST recordings completed during March to July, 2000 were obtained from Health Records at the University of Alberta Hospital. One EST recording was omitted due to technical difficulties during the test; three ESTs were not used because of uninterpretable tracings; one was not used, because there was no peak exercise tracing. The final sample consisted of 100 EST recordings that were prepared for analysis by research assistants. All identification markers were removed from the EST recordings.

Of the ESTs done, 99 used the Bruce Protocol; one EST used a ST Balke protocol.

The mean age of the patients for the sample EST recordings was 58.9 ± 12.05 years, with a range from 24 to 82 years. Body Mass Index (BMI) was calculated from the available data on the EST referral sheet; 4 referral forms did not include a weight so only 96 BMI calculations were available. The mean BMI for those 96 patients was 28.37 ± 4.58, with a range from 17.5 to 39.5. ESTs were done for 68 male patients and 32 female patients. Cardiovascular risk factor profiles and medications taken by the patients are listed in Table 4-1 and Table 4-2.

Table 4-1.
EST Patient Cardiovascular Risk Factors

CARDIOVASCULAR RISK FACTORS	N	Percent
None	54	54.0
Hyperlipidemia	18	18.0
High Blood Pressure	6	6.0
Diabetes	6	6.0
Family History	5	5.0
Smoking, Hyperlipidemia	3	3.0
Hyperlipidemia, Diabetes	2	2.0
Hypertension, Hyperlipidemia	2	2.0
Smoking	1	1.0
Hypertension, Hyperlipidemia, Diabetes	1	1.0
Hypertension, Hyperlipidemia, Family History	1	1.0
Hyperlipidemia, Family History	1	1.0

Table 4-2
EST Patient Medication Profile

MEDICATIONS	N	Percent
None	43	43.0
Beta Blocker	22	22.0
ACE Inhibitor	9	9.0
Beta Blocker, ACE Inhibitor	9	9.0
Calcium Channel Blocker	4	4.0
Nitrates	3	3.0
Beta Blocker, Nitrates	3	3.0
Beta Blocker, Calcium Channel Blocker, ACE Inhibitor	2	2.0
Beta Blocker, Ace Inhibitor, Digoxin	1	1.0
Calcium Channel Blockers, Nitrates	1	1.0
Beta Blocker, Calcium Channel Blocker	1	1.0
ACE Inhibitor, Nitrates	1	1.0
Beta Blockers, ACE Inhibitors, Nitrates	1	1.0

Characteristics of the ESTs

Mean EST length was 8.32 ± 3.21 minutes, with a range from 1 to 13.57 minutes. There were a variety of reasons for requesting the EST (Table 4-3). The most frequent indicator for the EST was to evaluate the patient with a known history of coronary artery disease (46.2%) and the second most common indication was to diagnose myocardial ischemia in patients without know cardiac disease (45.5%). One of the EST referral forms did not indicate a reason for the test. ESTs were terminated most frequently due to a combination of fatigue and dyspnea (47.5%). Fatigue alone was the second most common endpoint (25.3%), with ST depression and pain of various forms being the third most frequent (8.1%). See (Table 4-4).

Table 4-3
Indications for EST

REASON FOR EST	N	Percent
Previous CAD	46	46.2
Ischemia	45	45.5
Ischemia, Functional Capacity	19	19.2
Risk Stratification	7	7.1
Functional Capacity	5	5.1
Ischemia, Arrhythmia	2	2.0
Research	1	1.0
Ischemic Threshold, Functional Capacity	1	1.0
Arrhythmias, Syncope	1	1.0
Medication Response	1	1.0
Motor Vehicle License	1	1.0

Table 4-4
Reason for EST Termination

REASON FOR EST TERMINATION	N	Percent
Fatigue and Dyspnea	47	47.5
Fatigue	25	25.3
ST Depression, Pain	8	8.1
Target Heart Rate	4	4.0
Hypertension	4	4.0
Angina	3	3.0
Unable To Keep Up To Treadmill	3	3.0
Other Pain	2	2.0
Dyspnea	1	1.0
Arrhythmia	1	1.0
Paced Rhythm	1	1.0

Concordance Among the Raters

Kappa coefficients were calculated to assess agreement among the raters (NP, C1, C2) for EST baseline rhythm, arrhythmias during EST, and EST diagnosis. Pearson's correlation coefficients with regression plots were conducted to assess agreement among

the raters on baseline ST and peak ST segment levels.

Concordance on Baseline EST Rhythm

Baseline EST rhythms interpreted by the individual raters were classified into a total of 8 different categories as shown in Table 4-5. Of the 100 EST recordings, 87% were interpreted as normal sinus rhythm by each of the three raters. All three raters noted a Right Bundle Branch Block (RBBB) for 4 of the EST tracings. C1 and C2 noted Left Bundle Branch Block (LBBB) for 3 of the EST recordings, while the NP noted LBBB for only two of the EST tracings. A discrepancy was also noted for left ventricular hypertrophy, with C2 choosing that category for 5 patients, NP for 4 patients, and C1 for 3 patients.

Table 4-5
EST Baseline Rhythm Reported By Raters

Rhythm	NP (N)	C1 (N)	C2 (N)
Normal Sinus Rhythm	87	87	85
Atrial Fibrillation	1	1	1
Right Bundle Branch Block	4	4	4
Left Bundle Branch Block	2	3	3
Paced Rhythm	1	1	1
Left Ventricular Hypertrophy	4	3	5
Atrial Fibrillation and Left Ventricular Hypertrophy	1	1	1

Between the NP and C1 for EST baseline rhythm, the Kappa coefficient was .916 ($p = .000$); NP and C2 was .844 ($p = .000$); and for C1 and C2 was .844 ($p = .000$).

Concordance on Arrhythmias During the EST

Five categories of arrhythmias were noted by raters during the EST (Table 4-6). The categories were no arrhythmias noted, Premature Atrial Contractions (PAC) or Premature Nodal Contractions (PNC) combined, Premature Ventricular Contractions (PVC), 2nd degree atrio ventricular (AV) Block, and the combination of PAC, PNC and PVC. The majority of EST recordings were reported as having no arrhythmias; 75% by NP, 76% by C1, and 73% by C2. Kappa coefficients for arrhythmias during the EST could not be obtained for all of the EST recordings, as the raters identified different arrhythmias. Second-degree heart block was identified only by the NP and C1 and not noted by C2. Kappa coefficient between the NP and C1 on arrhythmias identified during the EST was .769 (p = .000); between NP and C2 was .732 (p = .000); and between C1 and C2 was .753 (p = .000).

Table 4-6
Arrhythmias During EST Reported By Raters

Arrhythmias	NP (N)	C1 (N)	C2 (N)
PAC or PNC	10	11	12
PVC	12	11	11
2nd Degree AV Block	1	0	1
PAC or PNC and PVC	2	2	3
None	75	76	73

Concordance on Baseline ST Segment Levels

Baseline ST measurements were done using a plastic ruler with finely graded increments or calipers. Baseline ST segment level was measured from the resting ECG using the PR junction as a guideline. Baseline ST levels were not obtained on those ECGs determined to be LBBB and therefore there were 3 missing values for C1and C2, and 2

missing values for the NP. The range of baseline ST segment levels for the NP was from -1.0 to 1.6; for C1, from -.70 to 1.6; and for C2 from -1.7 to 2.0. The highest agreement was between C1 and C2 ($r = .901$, $p < .001$). Concordance for baseline ST segment levels is noted in Table 4-7 and Figures 4-1 to 4-3.

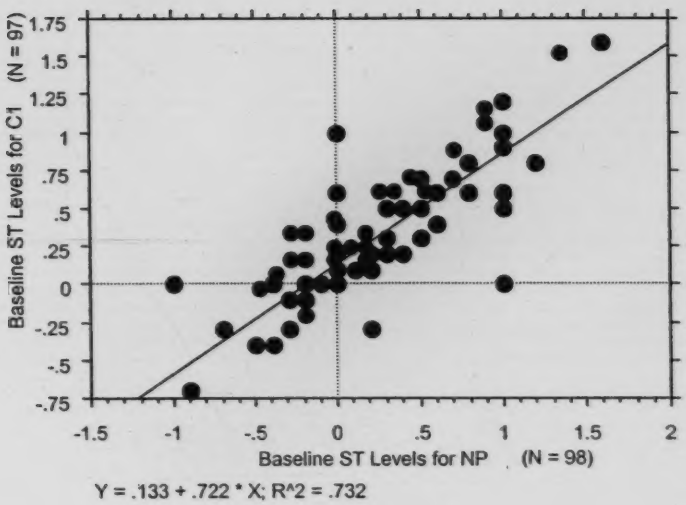

Figure 4-1. Concordance for Baseline ST Levels Between NP and C1

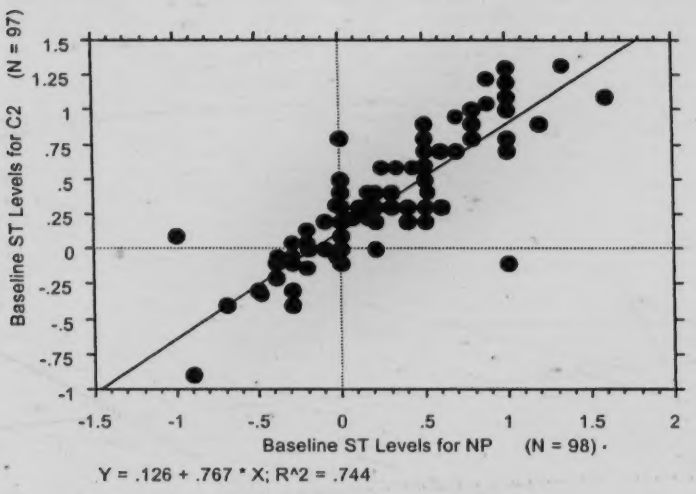

Figure 4-2. Concordance for Baseline ST Levels Between NP and C2

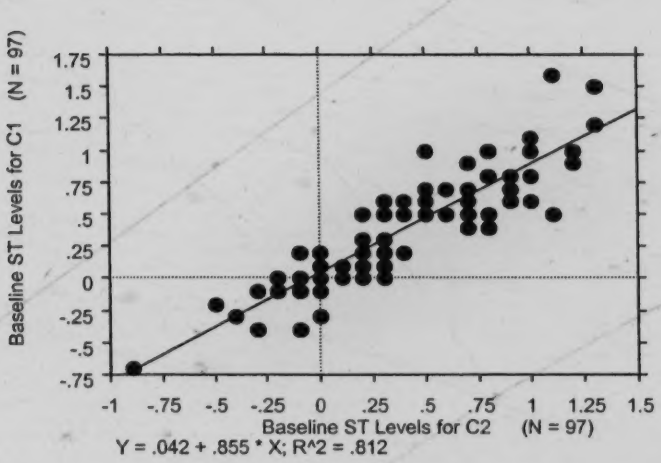

Figure 4-3. Concordance for Baseline ST Levels Between C1 and C2

Concordance On Peak ST Segment Levels

Peak ST segment measurements were evaluated using a plastic ruler with finely graded increments or calipers in the same way as the baseline ST segment measurements were done. Each rater was to select the first clear tracing after the peak exercise and

measure the lead with the maximum amount of changes. This was the value recorded and entered as the peak ST segment level. The NP had two missing values due to LBBB. The range of peak ST segment levels for the NP was –2.5 to 2.5 mm. C1 had three missing values due to LBBB, with a range from –4.0 to 2.5 mm; C2 had four missing values due to LBBB, with a range from –2.50 to 3.40 mm. The highest agreement was between the C1 and C2 ($r = .666$, $p < .001$). Concordance for peak ST segment levels is noted in Table 4-7 and Figures 4-4 to 4-6.

Table 4-7
Agreement of EST ST Segment Levels Among Raters

	NP and C1	NP and C2	C1 and C2
Baseline	0.856	0.863	0.901
Peak	0.579	0.480	0.666
* All agreements were significant at $p < 0.001$			

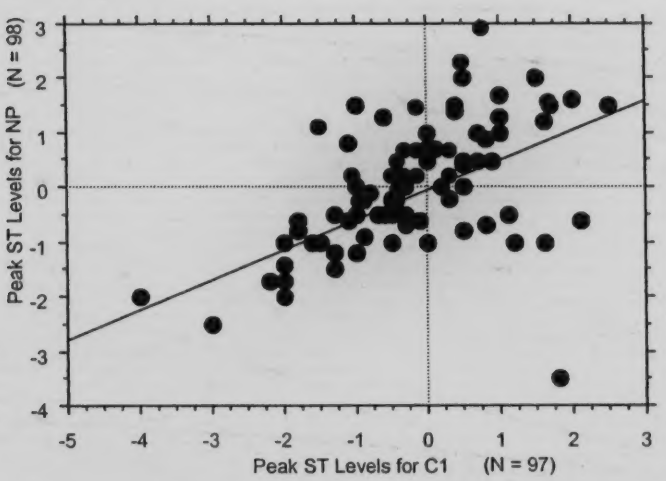

Figure 4-4. Concordance for Peak ST Levels Between NP and C1

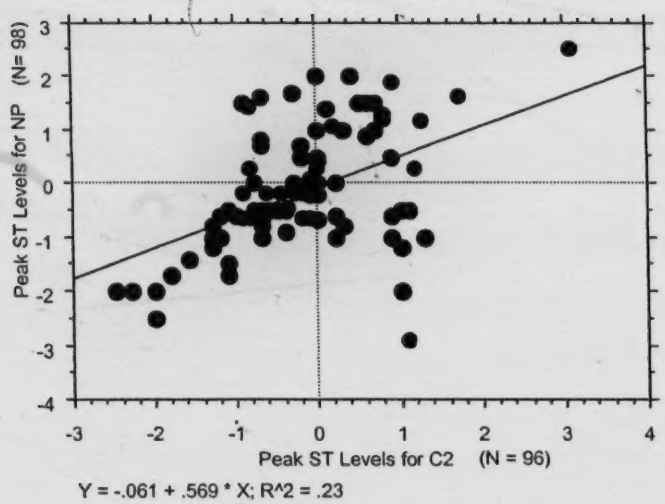

Figure 4-5. Concordance for Peak ST Levels Between NP and C2

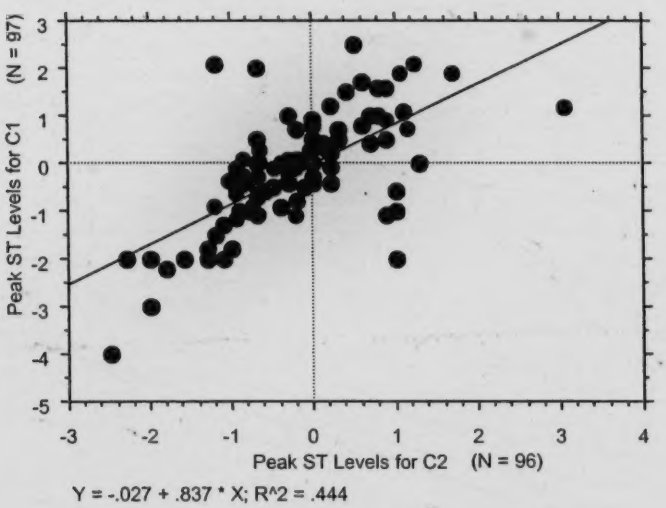

Figure 4-6. Concordance for Peak ST Levels Between C1 and C2

Concordance on EST Diagnosis

There were three EST diagnostic categories (positive, negative, and inconclusive). If an EST recording was not clearly negative or positive or if target heart rate had not been achieved, then the EST was considered inconclusive. Table 4-8 shows the frequency of the EST diagnosis chosen by each rater. Agreement between the NP and C1 on the EST diagnosis was a Kappa coefficient of .751 ($p = .000$); between NP and C2 was .728 ($p = .000$); and between C1 and C2 was .746 ($p = .000$).

Table 4-8
EST Diagnosis Among Raters

Diagnosis	Positive	Negative	Inconclusive
NP	18	53	29
C1	20	54	26
C2	12	56	32

Comparison to EST Computer Generated-Averaged Data

Comparisons were also done between the ST segment levels that the raters recorded and the levels that the computer generated-averaged measurements specified. To do this, the EST recordings were again obtained from Health Records and photocopied. The computer generated-averaged measurements for the information previously copied were photocopied. The computer generated-averaged measurements were then analyzed for the baseline ST segment levels for the three raters and for the peak ST segment levels for the NP and C1. Peak ST segment levels were not available to determine a comparison for C2. Baseline ECG data were obtained from the resting ECG and were available for some but not all of the ESTs done. The use of ESTs already completed limited analysis to that available on the Health Record. If the data were not obtained at the time of the EST, then the data were lost for that particular test. Thus data

were not obtained either because there was no baseline data or other computer generated-averaged measurements available for that particular Health Record, the data were uninterruptible due to baseline abnormalities such as LBBB, or the original Health Record could not be obtained from Health Records as it had been removed from the chart or the chart could not be located.

Concordance on Computer Generated-Averaged Baseline ST Segment Data

Baseline ST segment levels were unavailable or uninterruptible for 12 of the Health Records selected. All recordings for baseline ST analysis were taken from the resting data for lead V5. A simple regression analysis was done for the following: computer generated-averaged baseline ST segment levels versus levels recorded by the NP ($r = .848$, $p < .001$), computer generated-averaged baseline ST segment levels versus levels recorded by C1 ($r = .884$, $p < .001$), and computer generated-averaged baseline ST segment levels versus baseline ST levels recorded by C2 ($r = .929$, $p < .001$).

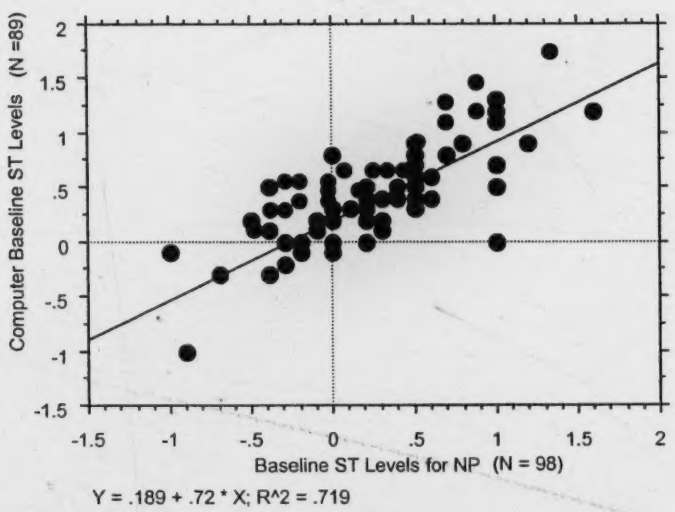

Figure 4-7. Concordance for Baseline ST Levels Between NP and Computer

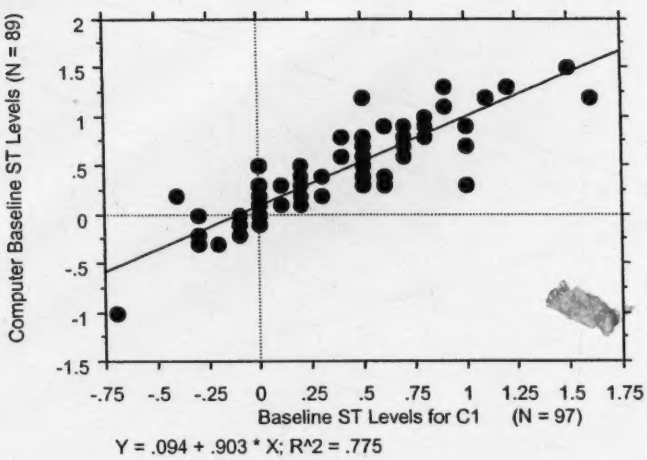

Figure 4-8. Concordance for Baseline ST Levels Between C1 and Computer

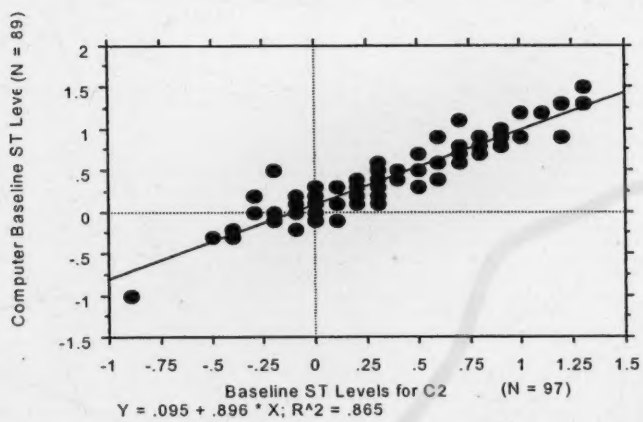

Figure 4-9. Concordance for Baseline ST Levels Between C2 and Computer

Concordance on Computer Generated-Averaged Peak ST Segment Levels

Analysis was also done on computer generated-averaged peak exercise ST segment levels. Peak ST segment levels were obtained and recorded by each individual rater according to the lead he/she considered most significant in the first readable recording in recovery. Typically, each rater chose different leads on different aspects of the EST and so a rater to rater analysis could not be done for this particular aspect of the EST. However, two of the raters had indicated which lead was used for analysis and therefore a simple regression analysis was obtained for the NP and C1 and the computer generated-averaged levels where available. Not all of the computer generated-averaged levels were available to be scored ($n = 84$ for the NP and $n = 76$ for C1) but an analysis was done for those that were available. The reasons for not being able to obtain the peak ST segment levels were: data not recorded for that particular recording, records not available on recall, or ST levels uninterruptible, as in the case of a LBBB.

Both the NP and C1 provided information as to the lead utilized in the analysis and the coefficients for peak ST segment levels were computed as follows: for the NP and the computer generated-averaged measurement, $r = .795$ ($p < .001$); for C1 and the computer generated-averaged measurement, $r = .907$ ($p < .001$).

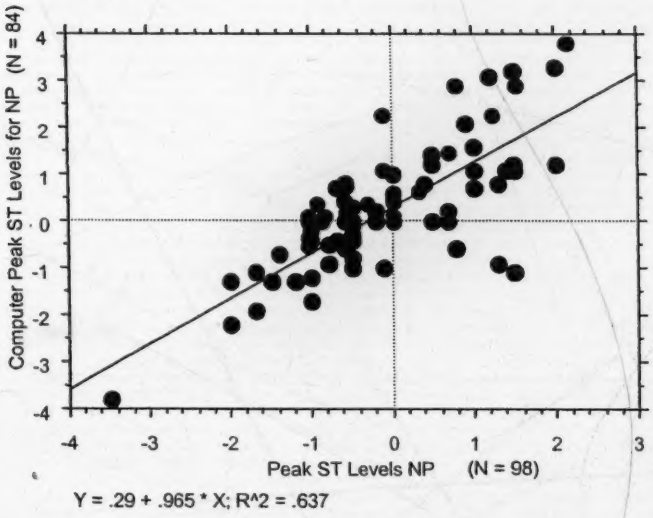

Figure 4-10. Concordance for Peak ST Levels Between NP and Computer

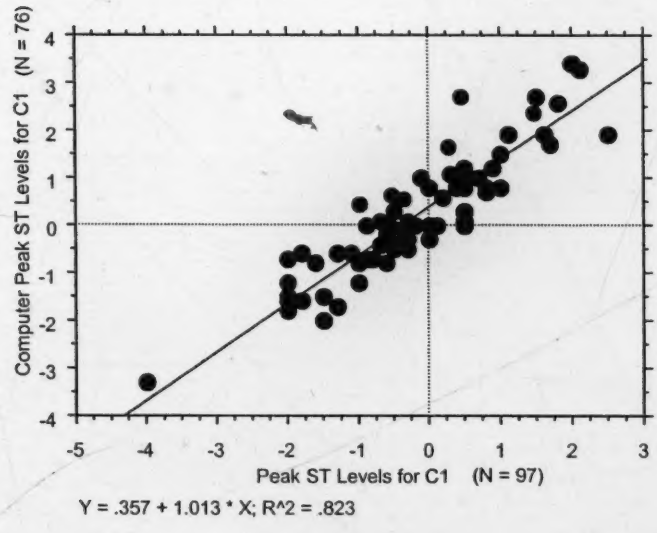

Figure 4-11. Concordance for Peak ST Levels Between C1 and Computer

CHAPTER FIVE

Discussion of Findings

The purpose of this study was to examine the reliability of a Nurse Practitioner (NP) in assessing ischemia on the basis of ECG recordings during an Exercise Stress Test (EST). One hundred EST recordings prepared by research assistants from ESTs done at the University of Alberta Hospital from March, 2000 to July, 2000 were reviewed independently by the NP and two Cardiologists (C1and C2). All reviewers were blinded to patient names so that the recordings could be judged impartially.

Sample Demographic Data

Patient demographic data were analyzed to determine if the sample was representative of the typical population seen for EST. Mean age of the sample was 58.9 years, with a range from 24 to 82 years. Mean body mass index was 28.37 (normal BMI is 20 – 25), with a range from 17.5 to 39.5. Men were 68% of the sample tested. These patient parameters are typical for the EST population (Senaratne, Smith, Gulamhusein, 2000; Zecchin et al., 1999; Lem, Krivokapich, & Child, 1985). Fifty-four percent of the patients had no risk factors noted on the referral form. Of the risk factors noted, the most common was hyperlipidemia (n=18), and hypertension was the second most common (n = 6). Risk factors are used as a guide in determining the probable likelihood of the EST being positive or negative. Forty-three percent of patients were on no medications. Of those medications listed, the most frequent was in the category of a beta blocker (n = 22); ace inhibitors alone or in combination with a beta-blocker were the second most frequent (n = 9). Often the initial EST referral form did not reflect the true information about patient risk factors or medications, as often the information was incomplete.

Concordance Among Raters

The parameters measured included agreement between the NP and Cardiologists on EST diagnosis, baseline rhythm, arrhythmias during the EST, and baseline and peak ST segment levels, as well as agreement with computer generated-averaged measurements. Agreement for ST measurements was established by measuring baseline and peak ST segment levels for each of the 100 EST tests used for this study. Agreement was assessed for arrhythmias noted during baseline and also those at peak or the recovery period of the prepared EST recordings. A Kappa coefficient was used to ascertain agreement between the raters for the EST diagnosis using the first clear tracing following peak exercise and recovery that was noted. Kappa coefficients were also used for agreement on baseline rhythm and arrhythmia analysis. Measurement for ST segment depression or elevation was done using a clear plastic scale ruler and or calipers, reading the first clear tracing after the peak exercise. Pearson's r was used to determine the agreement between the raters for ST segment levels.

Findings on EST diagnosis showed moderate agreement among all raters. A Kappa coefficient of .751 ($p = .000$) was found between the NP and C1; .728 ($p = .000$) between NP and C2; and .746 ($p = .000$) between C1 and C2. This minor variability that existed was likely due to intrarater differences in interpretation of the ESTs. Agreement was high on the ESTs that were clearly positive or clearly negative. The NP did not misdiagnose a strongly positive or strongly negative EST recording, which could compromise the patient's outcome.

Concordance on baseline rhythm showed high agreement among all raters with a Kappa coefficient of .916 ($p = .000$) between the NP and C1; .844 ($p = .000$) between NP

and C2; and .844 (p = .000) between C1 and C2. The NP diagnosed one of the ESTs as a non-specific conduction delay and therefore had one less diagnosis of Left Bundle Branch Block (LBBB) than C1 and C2. C1 rated three tests as left ventricular hypertrophy (LVH); the NP rated 4 tests as LVH; and C2 rated 5 tests as LVH. All raters were concordant on paced rhythm and atrial fibrillation as a baseline rhythm. Concordance was also noted on RBBB rhythm.

Agreement for arrhythmias during the EST was moderate for all three raters with a Kappa coefficient between NP and C1 of .769 (p = .000); between NP and C2 of .732 (p = .000); and between C1 and C2 of .753 (p = .000). The major variance here was that the NP and C2 had noted a second-degree AV block in one of the ESTs, where C1 did not. The other variances between the raters were mostly due to the differences in diagnosing PACs, PNCs, and PVCs.

Agreement on baseline ST segment levels was high among the three raters, with r = .856 (p< .001) between the NP and C1; r = .863 (p< .001) between NP and C2; and r = .901 (p < .001) between C1 and C2. Agreement was high due to the fact that all raters were analyzing the same data, V5, on the resting ECG. The minimal variance in reading the ST segment levels would have been due to difficulty in reading the black on black print and the individual methods used in reading the ST segment levels.

Agreement for peak ST segment levels was lower between the three raters than the baseline ST segment levels. Agreement for peak ST segment levels was r = .579 (p< .001) between the NP and C1; r = .480 (p< .001) between NP and C2; and r = .666 (p< .001) between C1 and C2. Unlike the baseline ST segment level measurements, the peak ST segment level measurements were not all read using the same ECG lead by all the

raters. Each rater chose the ECG lead closest to the peak performance reading that they thought could be read the most clearly. Each rater was also to choose the ECG lead that was thought to have the most ST depression or elevation. Variability occurred in the ECG leads chosen, accounting for the low agreement noted for peak ST segment levels.

Concordance between the baseline ST segment levels and the computer generated-averaged measurements for the baseline tracing of V5 lead showed high agreement among the raters, with $r = .848$ ($p < .001$) for the NP; $r = .884$ ($p < .001$) for C1; and $r = .929$ ($p < .001$) for C2. The computer generated-averaged measurements are not considered the "Gold" standard but are a useful unbiased comparison. Computer generated-averaged measurements are subject to error, as the measurements are on a baseline that shows movement. Markers used to determine ST segment levels as determined by the computer are also sometime incorrect. The computer generated-averaged measurements are an average of the values selected at a precise point in time, and frequently recorded approximately 10 seconds later than the ECG recordings. Changes in ST segment levels can occur during this time period accounting for some of the variance among raters noted. As well, variances could have occurred due to the difficulty of reading the black on black tracing.

Concordance on computer generated-averaged peak ST segment levels was moderate for the NP with $r = .795$ ($p < .001$), and high for C1 with $r = .907$ ($p < .001$). The same limitations that applied to the reading of the baseline ST segment levels would apply to the peak ST measurements as well. Due to the fact that different ECG leads at various stages of the EST were used also accounts for some of the variability among the raters. Some of the variability might also be accounted for by the fact that computer

generated-averaged measurements were available for 76 of C1's ESTs and 84 of the NP's ESTs. The NP typically chose to read peak ST levels later in the test than did C1 and computer generated-averaged data were more frequently available for the late readings. For data closer to the actual peak of the test, the computer generated-averaged data were frequently overriden in favor of the current ECG tracing.

No literature was found to do a comparison to the current study. One study (Zecchin, Roach, et al., 1994) did suggest that NPs in the study agreed 94% of the time with the diagnosis made by the Cardiologists. In practice, at the University of Alberta Hospital variability has been noted between the Cardiologists in the interpretation of the ECGs. To date no scientific data have been available.

Limitations of the Study

The use of retrospective data was a limiting factor. Some of the data was not obtained at the time of analysis. Data that was missing included information typically collected prior to an EST, such as cardiac risk factors and current medications. During the EST, some of the computer generated-averaged measurements that can only be collected at the time of testing were also missing. When an EST is done and interpreted in an everyday situation, the NP or Cardiologist would have the whole recording available for interpretation. This would include the computer generated-averaged measurements, as well as all of the recordings that were done for that individual. Whenever retrospective data is used, vital information can be missing. This information would be very valuable in making decisions for the ESTs that have borderline positive or negative recordings. A study design using prospective data could eliminate this problem by ensuring that all data required were collected.

Another limiting factor was that the photocopied recordings were also difficult to read due to the coloring scheme and the fine grading of the ECG paper. On the original tracing the paper is red with the ECG recording lines appearing in black. The photocopied ECG recordings were black on black and therefore more difficult to read. Photocopied tracing were used in order to ensure patient anonymity. The very fine grading of the graph paper also made accurate reading difficult. This fine grading of the paper was the most limiting feature of the study. It is difficult for the human eye to determine exactly where to read the ST segment. Magnification of the lines would have been helpful but were not considered for this study. Future studies could include the use of a simple magnifying glass.

Two different methods of determining ST segment levels were used, a clear plastic ruler and calipers. Standardizing this method could reduce some of the variation; however, this would again be different from the everyday situation. Cardiologists determine ST segments using a variety of methods, including pen and paper with an estimation of the ST segment level.

This study was limited to one NP and two Cardiologists at the University of Alberta Hospital and cannot be generalized to other individuals or settings. This NP had considerable experience in Cardiology and in reading exercise ECGs, as well as training in EST interpretation.

Implications of the Findings

The concordance of the raters overall was moderate to high, suggesting that a well-trained NP is as reliable in reading ESTs as experienced Cardiologists. Variability

did exist between raters as was noted between the two experienced Cardiologists themselves.

Implications for future studies would be to have stricter controls in designing the study. It was left to the individual interpreting the EST to decide which recording to read, and as a result a number of different stages of the EST were used to make a decision about each test. This is where most of the variability among raters occurred. Concordance among the three raters was high in determining the ST levels of the baseline EST recordings. This was due to the fact that all raters read V5 on the baseline recording. For peak ST segment levels, there was a higher degree of variability due to the fact that different ECG leads were read, as well as variability in the timing of the ECG tracings considered for interpretation. If exactly the same beats were read using the same technique, concordance would likely have been higher. Concordance was high when all three raters interpreted the same lead on the baseline ECG tracing. Being able to use the original data rather than a photocopied reproduction would also ease interpretation. Designing a study using prospective data would allow for all of the information to be collected and subsequently reduce the amount of missing data.

Conclusion

Concordance among the three raters was high in baseline rhythm and baseline ST segment levels; moderate agreement was found on EST diagnosis and arrhythmias during the EST. Agreement varied from moderate to high between the raters on the computer generated-averaged measurements for baseline and peak ST segment levels. Agreement on peak ST segment levels was low due to the fact that different ECG leads were interpreted. Thus the NP and Cardiologists had moderate to high agreement on various

aspects important to the interpretation and diagnosing of ESTs. NPs are continuing to have an impact in the health care environment. Research evaluating the role of NPs will assist in the development and acceptance of the NPs as a reliable member of the health care team.

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Appendix A

NP Job Description

Current Class Level: E70 Name of Incumbent:

Working Title: Advanced Nurse Practitioner (ANP) In- or Out- of Scope: Out of Scope

Program/Department: Cardiology Cost Centre: 71205100041

New Position X Update ☐ Request for Classification Review
☐

❖ *PLEASE ATTACH A CURRENT ORGANIZATIONAL CHART* ❖

PLEASE REFER TO ATTACHED INSTRUCTION GUIDE FOR ASSISTANCE IN COMPLETING THIS FORM.

I POSITION SUMMARY (Overview; main purpose)

The Advanced Nurse Practitioner (ANP) is a self-directed practitioner who functions in an extended role in the area of Cardiology. In collaboration with Cardiologists, nurses and other health team members, the Advanced Nurse Practitioner provides direct patient care using advanced assessment skills and a knowledge of clinical therapeutics for the purpose of assessment, diagnosis, intervention management, referrals and management of patients with cardiac disease across the continuum of health care services. All duties and responsibilities of the Advanced Nurse Practitioner will follow the guidelines developed by the Alberta Association of Registered Nurses, the University of Alberta Hospitals, and the practice protocols of the Division of Cardiology.

The Advanced Nurse Practitioner will report to the **Patient Care Director, Cardiac Sciences** and to the Director, Division of Cardiology.

II KEY RESPONSIBILITILIES (what is done and how; in order of importance; utilizing action verbs)

A. Duties and percentage of time spent on each: (refer to instruction guide for percentage breakdown)

1.0 **(80%) Clinical Practice**

- 1.1 Contribute to the continuing education of health care team members about the management of patients with cardiac diseases through case consultation, clinical demonstration, or bedside rounds.
- 1.2 Assess the physical and psychological health status of patients by means of interview, history, and physical examination.
- 1.3 Identify the patient's health care problems and develops a plan of care.
- 1.4 Document his/her assessment, plan, intervention and evaluation of patient care.
- 1.5 Perform selected diagnostic and therapeutic interventions in consultation with the attending physician following agreed upon clinical protocols (Appendix A).
- 1.6 Interpret laboratory, radiological, or other tests results in consultation with the attending physician.
- 1.7 Promote continuity of patient care through daily assessment and evaluation of the patient population.
- 1.8 Requests consultation from physicians and other health care professionals following agreed upon standards of care.
- 1.9 Liaison with health care team members regarding patient care, progress, and outcomes.

1.10 Provides health education and counseling to the individual or family to assist in coping with the disease process.

1.11 Collaborate with patients and families, nurses, physicians and other health care professionals in the provision of care.

2.0 **(20%)** **Professional Practice**

2.1 Provide leadership in the development of revision of research based clinical protocols and guidelines.

2.2 Identify the need for change related to clinical, educational, or research issues in clinical practice.

2.3 Maintain competency in the skills and knowledge necessary for advance practice nursing.

2.4 Analyze and interpret current research/literature applicable to the care of the cardiac patient.

2.5 Participate in professional organizations and activities that will promote the advancement of nursing knowledge.

2.6 Present at and/or attend regional and national conferences related to clinical and national conferences related to clinical specialty.

2.7 Facilitate clinical research by identifying research issues, supporting current investigations, or conducting clinical research.

2.8 Serve as a role model for professional nursing practice.

2.9 Collaborate with the Faculty of Nursing, University of Alberta.

B. Most difficult and/or complex aspects of the position: (difficulty; analysis and decisions required; availability of information; problems encountered)

C. Diversity and scope of services delivered: (variety; breadth and depth; impact; magnitude)
Status of Work:

Clinical decisions are made in conjunction with the physician and health care team using clinical practice guidelines, department and hospital policies and procedures and expanded knowledge base. Quality Improvement and Accreditation Standards are met.

III ADMINISTRATIVE RESPONSIBILITY

A. Human Resource/Workforce Characteristics

Supervision Exercised: (direct, indirect and functional/shared reports; numbers, status and levels; nature of supervisory relationship)

Members of the health care team in clinical settings and emergency situations.

Supervision Received: (name, title, and level of immediate supervisor; extent of supervision received)

Reports clinically to the Chair of the Division of Cardiology and his designates
Reports administratively to the Patient Care Director, Cardiology

Workforce Characteristics: (variety of sites, locations, and collective agreements; staff composition; other characteristics e.g. continuous operation)

Single site Acute Tertiary Care teaching hospital

B. Financial Responsibility

Budget/Financial: (size of operational and capital budgets; nature of financial resource management role including budget development, accountability, and decision making)

No direct financial management.

Funding/Grant responsibility: (responsibility for sourcing and administering funding)

Scan environment for funding sources from grants, special funds, contingencies etc.
Develop proposals for accessing such funds.

IV DECISION-MAKING/ACCOUNTABILITY

A. Decision-Making/Independence:

Decisions/Judgment exercised: (solutions developed and implemented; creativity and originality; latitude to function independently)
Recommendations: (decisions/judgments referred to supervisor for discussion; examples as outlines for decisions/judgments

Delegated medical acts are:

- A prescription for a range of treatments or interventions aimed at the patient population on the Cardiology wards and for which an individual physician assumes responsibility;
- Developed collaboratively and reviewed annually; and
- May be implemented only by the Advanced Practice Nurse – Cardiology who possesses the required skill, knowledge and judgement regarding the patient problem, the treatment being considered, potential outcomes and solutions.

Delegated medical acts include:

- Medications
- Diagnostic tests
- Procedures
- Communicating/clarifying/confirming a diagnosis

Medications, tests, consultations, procedures and diagnosis that may be initiated or communicated are specific to the practice of Cardiology and the individual physician.

Specific Circumstances

- Questions/clarifications regarding orders arising from the delegated medical acts should be directed to the Advanced Practice Nurse. If the nurse is unavailable or further clarification is required, the attending physician or Resident should be contacted.

- Untoward events arising from the initiation of the delegated medical acts should be relayed to the Advanced Practice Nurse and the attending physician or Resident. Documentation should be initiated by the Advanced Practice Nurse and the identifier.
- Documentation of orders initiated under these medical directives are to be written and signed as follows:

Contraindications

Contraindications for the implementation of the delegated medical acts include specific or known contraindications for each of the tests, procedures, known drug allergies or conditions precluding the implementation of tests, procedures or medications.

Conditions

In patients or out-patients must be under the care of the Cardiology Service.

The attending physician must be available by telephone

The patient must consent to treatment

The Advanced Practice Nurse performing the treatment must have:

- The knowledge, skill and judgement to perform the treatment
- The knowledge, skill and judgement to manage all possible outcomes of the treatment and;
- The resources available to perform and manage the outcome of the treatment

DELEGATED MEDICAL ACT # 1
Medications

The Advanced Practice Nurse – Cardiology is authorized to prescribe those medications the patient was receiving at the time of admission as long as the drug, dosage, and frequency of administration are deemed appropriate.

Orders may be processed and executed without a co-signature

Co-signature from the attending physician must be obtained within 24 hours.

MEDICATION	EXAMPLE	LIMITATION
ACE Inhibitors	Captopril, Enalapril, Lisinopril,	If previously ordered
Analgesic	Acetominophen, Acetominophen with codeine, Fentanyl, Meperidine, Morphine,	
Antacids	Diovol, Gaviscon, Maalox, , Sulcrafate	
Antiarrhythmics	Atropine, Lidocaine, Procainamide, Adenosine, Digoxin, Amiodarone	In an emergency (ACLS) If previously ordered
Anti – microbials		As per culture and sensitivities
Anticoagulants	Unfractionated Heparin, Low molecular weight heparin, Warfarin	As per nomogram As per PT/INR
Anti-convulsants	Phenytoin, Tegretol	If previously ordered
Antiemetics	Dimenhydrinate, Domperidone, Metoclopromide, Prochlorperizine	
Anti – gout	Allopurinol, Colchicine,	
Anti – histamines	Atarax	
Antihypertensives		If previously ordered
Anti-inflammatory	Ibuprofen	
Antiplatelet	Aspirin, Ticlopidine, Plavix	
Asthma therapy	Albuterol, Beclomethasone, budesonide, fluticasone, ipatropium	
Beta Blockers	Atenolol, Metoprolol, Nadolol, Sotolol,	As per admission protocol

MEDICATION	EXAMPLE	LIMITATION
	Bisoprolol	If previously ordered
Calcium Channel Blocking Agents	Amilodipine, Diltiazem, Nefidipine, Verapamil	
Diuretics	Furosemide, Metolazone, HCTZ, Spironolactone	
Electrolytes	Potassium Chloride, Magnesium Sulphate, Kaexylate	
Anti – ulcer therapy	Ranitidine, Losec, Prevacid, Pantoloc,	
Hypoglycemic agents	Diamicron, Gliclazide, Glyburide, Metformin	As previously ordered
Hypnotics/sedatives	Lorazepam, Chloral Hydrate, Diazepam, Zopiclone, Loxapine	
Inotropes	Dobutamine, Milrinone	As per low dose protocol
Insulins	All insulins Regular insulin	As previously ordered Treatment of high blood sugar
IV Solutions including Saline flush for locks		
Laxative/Stool softeners	Docusate Sodium, Fleet Enema, Sennosides, Lactulose	
Lipid Lowering Agents	Statins, fenofibrate	
Nitrates	Nitroglycerine SL, Nitro patch, Isosorbide mononitrate	

DELEGATED MEDICAL ACT # 2
Diagnostic Tests

PROCEDURE	PARAMETERS
1. Laboratory • Hematology • • Urinalysis • Electrolyte • Glucose • Drug screens • Cardiac enzymes • Lipid profile • Cross match • Coagulation: pt/ptt, d-dimer • Microbilogy • Blood cultures • Blood gases • Stool for Occult blood, ferritin, TIBC, bilirubin, vit B12, peripheral smear • Liver function tests • HgA1C • HIT assay • TSH • Lipase	• Admitting blood work, suspected bleed, monitoring anemia/infection/thrombocytopenia • Admitting, unexplained fever, dyspareunia • Admitting, following diuresis • Suspected toxicity • Suspected M.I. • Pre-operative, significant bleeding • Monitoring of anti-coagulant therapy, suspected pulmonary embolism • Unexplained fever; elevated WBC • Unexplained fever; elevated WBC • Pre-op, suspected respiratory distress • Unexplained anemias Suspected liver disease; prior to initiating statin therapy or amiodarone Monitoring diabetic control Suspected HITT Atrial arrhythmias, prior to starting amiodarone Suspected pancreatitis

2. Radiology • Chest • Abdomen – flat & 3 views • Ultrasound • • Carotid dopplers • Venous dopplers	• Admission, unexplained dyspnea • Unexplained abdominal discomfort • Suspected A-V fistula, false aneurysm, post angiography • Pre-op assessment; carotid bruit • Suspected deep vein thrombosis
3. Cardiology • Electrocardiogram • Exercise stress test • Echocardiogram	• Chest paid NYD • Pre-discharge and PRN
4. Nuclear Medicine • MIBI • Viability screen • VQ Scan	
5. Other • Telemetry • Vital sign monitoring • Diet • IV therapy • Capillary glucose monitoring • Pulse oximetry • Activity • Bladder catheterizations • Intake/output • Weights • Pulmonary function testing Admission orders Transfer orders Discharge orders Consults: • Home care • Palliative care • Geriatric assessment • OT/PT/dietician/social worker	Preop assessment; prior to initiating amiodarone

DELEGATED MEDICAL ACT # 3
Procedures

Procedure	Parameter
• Removing arterial/venous introducer sheaths	Post angiogram, angioplasty
• removal of central lines	Venous access for inotropic therapy or in the absence of other peripheral intravenous sites
• Cardiac arrest management including defibrillation	Until arrival of Code Team
• Removal of right ventricular transvenous pacing catheter • Adjustment of temporary pacemaker settings (rate, mA)	In the presence of a stable intrinsic rhythm or post implantation of a permanent pacing catheter Failure to sense or capture

B. Results or Outcomes expected of position: (accountability for products/outcomes; position and program objectives to be achieved)

C. Impact of Decisions/Actions (impact of decisions; impact and likelihood of an error)

Patient injury or death could occur as a result of improper clinical decisions and/or care. Checks in place include hospital policies specifying the scope of practice of the ANP, the special education program completed with the Faculty of Nursing, and physicians understanding and support of the role

V CONTACTS (typical contacts: internal and external; nature of contact: reason for contact and impact)

A. Internal & External:

Internal	**Nature**	**Frequency**	**How**
Cardiology Team Members	Clinical Care of Patient	Daily	In person, phone, pager
Patients	Clinical Care	Daily	In person
External	**Nature**	**Frequency**	**How**
Faculty of Nursing	Promoting Nursing Care Standards, knowledge and skills	Weekly	In person, phone
Health Care Agencies	Supporting patient care	As required	In person, phone
Other Hospitals	Patient care issues	As required	In person, phone

VI QUALIFICATIONS (minimum essential qualifications; of position not incumbent; kind and amount

A. Formal Education: (post-secondary degrees, diplomas, certificates, etc.)

The Advanced Nurse Practitioner will have completed a Master of Nursing program with a nurse practitioner component or a recognized equivalent graduate program with a diploma in Advanced Nursing Practice

B. Training: (special training courses which supplement formal education and which are required in order to commence in the position)

Certification in Advanced Cardiac Life Support is mandatory.

C. Experience: (kind and amount in months or years)

Relevant clinical experience in the area of Cardiology is required

D. **License(s)/Certificate(s):** (may include drivers' license, certification to perform specific duties)

E. **Professional Membership(s):** (professional certificates, registrations, designations, etc.)

Membership or eligibility for membership in the Alberta Association of Registered Nurses.
Eligible for associate appointment with University of Alberta Faculty of Nursing.

VII **SPECIAL KNOWLEDGE/SKILLS/ABILITIES/COMPETENCIES** (attributes required of a fully functioning incumbent)

A. **Knowledge:** (examples include knowledge of the program area, other programs, the organization, computer applications, medical terminology, etc.)

- Library, computer, research skills.

B. **Skills/Abilities/Competencies:** (includes interpersonal skills, conflict resolution, organizational skills, etc.)

- Highly developed organizational skills and problem solving ability
- Demonstrated clinical leadership
- Strong interpersonal oral and written communication skills
- Demonstrated creativity, flexibility and initiative
- Effective change agent

VIII **SPECIAL REQUIREMENTS/UNIQUE ASPECTS OF JOB:**

A. **Physical Exertion:** (heavy manual work, standing entire shift, equipment operation, lifting, etc.)

- Walking, sitting, standing, lifting associated with patent care and desk work
- Must be able to work with heavy patients and occasionally work in awkward positions to deliver patient care.

B. **Environmental Conditions/Characteristics:** (hazardous and climate conditions)

Exposure to patient matter, infectious diseases. Works in the Ward Environment, Emergency Department and Exercise Testing Laboratory.

C. **On-the-Job Training:** (additional training provided which is necessary to perform the role)

- In depth education and clinical practice on new therapies

D. **Other:** (amount of travel; numerous interruptions; involvement in confrontational situations, etc.)

- Multiple conflicting priorities
- Frequent interruptions

IX **CHANGES SINCE LAST REVIEW** (a summary of changes which impact on role i.e. summary of new and/or deleted duties, organizational changes, etc.)

X **AUTHORIZATION:**

Employee: _____ **Date:** _____

Supervisor: _____ **Date:** _____

Human Resources: _____

Appendix B

Guidelines for Interpretation

Guidelines for Interpretation

1. PR will be used as baseline for measurement of the ST segment

2. V5 to be used for interpretation in all cases as well as lead showing maximum ST depression or elevation. Lead used for max interpretation needs to be identified on recording sheet.

3. Consider test positive if ST depression 1 mm or more 80 ms from the J point if flat or downsloping in the lead with max depression. 1.5 mm if upsloping. Slope considered upsloping, flat or downsloping noted based on positive, absent or negative direction from isoelectric line measurement 40 to 80 ms. from the J point. Depression should be noted in at least 3 consecutive beats. (use the beats have flat or downsloping tendencies or the least variation in movement).

4. Positive also should be noted if more than 1 mm elevation noted from resting value in a lead with no Q waves.

5. If a lot of artifact noted on peak tracing and it is impossible to clearly see baseline and deflection, evaluate test based on the first clear tracing in recovery.

6. If LBBB don't determine level. Consider test inconclusive for ischemia.

7. If RBBB don't determine st level leads V1- V4.

8. If on Dig and ST depression detected determine level of ST depression but consider test inconclusive

9. If Atrial flutter or fibrillation and unable to determine baseline consider test inconclusive. Do not measure.

10. If severe artifact in all leads consider test inconclusive due to uninterpretable baseline.

11. With LVH determine ST level but if qualifies for positive consider test inconclusive. LVH criteria to be greater than 35 mm using S in V2 and R in V6. Also if greater than 11 mm in AVL.

Appendix C

Data Collection Sheet

Data Collection Sheet

Rater # _____

Test I. D. #: _____

Patient Demographics: Age_____ Gender_____ Height_____ Weight_____

Risk factors identified (from information available):

1) High Blood Pressure_____ 7) Family History_____
2) Smoker_____ 8) Diabetes____
3) Hyperlipidemia_____

Medications:

1) Beta Blocker_____
2) Calcium Channel Blocker_____
3) A.C.E. Inhibitor_____
4) Digoxin_____
5) Nitrates_____

6) Other _____

Reason for the test:

Protocol utilized:

Test length:

Reason for test termination:

Angina during the test: Yes_____ No_____

Baseline Rhythm:	**Arrhythmias During Test:**
1) Normal Sinus Rhythm_____	1) PAC PNC PVC
2) Atrial Fibrillation_____	2) 3rd ° AV Block _____
3) Right Bundle Branch Block_____	3) 2nd ° AV Block _____
4) Left Bundle Branch Block_____	4) Ventricular Tachycardia _____
5) Paced Rhythm_____	5) SVT _____
6) Left Ventricular Hypertrophy_____	6) LBBB _____
	7) RBBB _____
7) Other _____	8) Other _____

Baseline ST depression:_____mm.

Maximum amount of ST depression noted during test: _____ mm.

Diagnosis: Positive EST_____ Negative EST_____ Inconclusive EST____

Comments: